ARTICLE II.

ON SIMULTANEOUS LIGATION OF THE COMMON CAROTID AND OF THE SUBCLAVIAN IN ITS THIRD PORTION IN THE TREATMENT OF SUPPOSED ANEURISM OF THE ARTERIA INNOMINATA, WITH A CASE.

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ON the 21st of November, 1865, Mr. Christopher Heath performed for the first time the operation of simultaneous ligation of the common carotid and of the subclavian in its third portion for the cure of innominate aneurism. The idea was not a new one, and operations for the same disease, closely allied or identical in principle and in the means by which the proposed effect was sought to be produced, had been performed during the preceding half century.

The principle of distal ligation in cases which do not admit of the application of a ligature upon an artery between the heart and the aneurism had been orally suggested by Brasdor, professor of surgery in Paris, as early at least as the year 1790, and the suggestion had been repeated in print by his contemporary Desault,[1] but neither surgeon had acted upon it; Brasdor, apparently, not having had the opportunity, and Desault refraining in a case of axillary or subclavian aneurism that came under his care through fear of causing rupture of the sac by the increased pressure which he supposed would be produced within it by the closure of the artery. The first operation upon this principle was performed October 2, 1798, by Deschamps,[2] who tied the femoral artery in the middle of the thigh for the cure of a large aneurism, the upper border of which was less than a finger-breadth below Poupart's ligament. Rupture threatening on the fourth day, another operation was determined upon; the artery was compressed against the pubis, the sac opened, and the vessel tied above and below. The hemorrhage was profuse, and the patient died in eight hours. Brasdor, who died shortly afterwards, was present at this operation, as were also Boyer, Corvisart, and six other consultants.

The second operation was by Sir Astley Cooper, who tied the common femoral below the origin of the epigastric artery for a large aneurism of the external iliac. The patient recovered from the operation, and the aneurism diminished in size, but it continued to pulsate and ruptured soon afterwards.

In 1809 or 1810, Mr. Wardrop saw in consultation a case of supposed aneurism of the innominate and the root of the carotid, and, being familiar with the facts above mentioned, proposed to tie the carotid artery. The proposal was not favourably received by the other consulting surgeons, and the patient was left to his fate, dying within the year. The condition of the vessels disclosed at the autopsy is claimed by Mr. Wardrop, in his book on aneurism published in 1828, to have been curable by the operation he proposed, but as the aneurism proved to be of the ascending aorta and root of the innominate, and not of the innominate and root of the carotid as he had supposed, it seems likely that this claim was the result of his later experience.

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[1] Œuvres chirurgicales, third edition, edited by Bichat, vol. ii. p. 568.

[2] Desault, loc. cit. p. 572.

It is interesting to trace the manner in which the Wardrop method of distal ligature, as we now understand the term, was developed: the method, that is, which proposes to cure an aneurism by slowing the current through it, not by arresting it entirely. Our knowledge of the method recommended by Brasdor is purely traditional, for he left no written account of it. Our conception of it, however, is the application of a ligature on the distal side of an aneurism with no intervening arterial branch between them. Whether or not Brasdor intended to restrict it thus to cases in which the circulation through the aneurism would thereby be completely arrested, is not known. Probably his idea was not very sharply defined in his own mind. It was known at the time that complete arrest of circulation was not necessary to the success of the Hunterian method by ligation on the proximal side, and, as Dr. Sands has well shown in a paper upon "The Distal Operation for the Cure of Aneurism of the Innominata,"[1] intervening branches did exist between the sac and the ligature in the first two operations undertaken in accordance with Brasdor's suggestion; and in the first case in which Wardrop proposed to try it the subclavian was supposed to come off from the aneurism itself or on its distal side, and he nevertheless speaks of it as Brasdor's operation. Writing seventeen years after he had made this proposal, and two years after he had successfully treated an aneurism of the common carotid by distal ligature, and shortly after his successful operation upon Mrs. Denmark (ligation of the subclavian in its third portion for innominate aneurism, the carotid being thought to be occluded), Wardrop claims that his success had established the principle contained in Brasdor's proposal, and explains the previously infrequent recourse to the operation by the fact that surgeons had taken too limited a view of its application, and had deemed the complete stoppage of the circulation a *sine qua non* to its success; adding that cases considered suitable under such a theory must have been extremely few. These are his own words, and it must be evident to any one who will read his book carefully and seek out the meaning of his sometimes obscure and carelessly framed sentences, that by the "new operation" which he recommends he means only a modification of Brasdor's to this extent, that in cases where a complete or almost complete arrest of circulation through an aneurismal sac was not possible he would try the effect of a *moderate* reduction in the rapidity of the current.

There is nothing in this view to detract from the credit due Wardrop.

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[1] Medical Record, February 1, 1869, p. 531.

As we have seen, Brasdor only made the suggestion; Desault, with whom, as is claimed by some, the idea was also original, shrank from putting it into execution; Deschamps and Sir Astley Cooper did the operation unsuccessfully, and these failures were followed by a general discrediting of the principle. Allan Burns, writing in 1812, says of it: "I cannot conceive a more futile idea than to suppose that such an operation could possibly tend to prevent the growth of an aneurismal sac;" and again, "there is no point in the treatment of aneurism which should be more decidedly reprobated than this; it is absurd in theory, and experience proves that it is ruinous in practice." The warmth with which this opinion is expressed may have had its origin in the fact that Burns was employed in the case in which Wardrop first advised the operation and was overruled. It is not surprising that Wardrop took occasion to quote this opinion in connection with the record of his own subsequent successes.

In spite of this hostility and of these reverses, Wardrop accepted and adhered to the principle, and he did this not blindly but with an intelligent appreciation of facts disregarded by others. He had the courage of his opinion, he acted upon it, and he convinced others of its correctness. He established the principle, he was the real introducer of the method, and his is the credit.

Nearly fifty years had elapsed since the suggestion was first made, and at least twenty years since the two attempts to embody it in practice had failed, when Wardrop found his first opportunity. Fifteen years previously he had proposed the operation in consultation, and had been overruled; now the case was his own. The patient was a woman 57 years old, with a carotid aneurism of recent growth. Wardrop tied the artery on the distal side in June, 1825, and cured the disease. Six months later he repeated the operation in another case "in the presence of many practitioners," and again a year later he advised it and was present at its performance.[1] The publication of these cases was followed in 1828[2] by that of the fourth, in which the operation, also for carotid aneurism, was done successfully in September, 1827, by George Bushe.

Wardrop held that the results of these four cases proved the propriety of resorting to distal ligature when no branch intervenes between the ligature and the sac, and when ligation on the cardiac side is impracticable; and he argued, from certain observations made in the course of these cases, that it was often even to be preferred to the Hunterian method when the latter was possible. He then went a step further, and this is what he calls the "new operation," and claimed that aneurism of the innominate might be successfully treated by ligature of one of the branches of that artery. His argument is as follows: Knowing from the observations of Sir Everard Home and later writers that complete arrest of the circulation was not essential to its cure, but that a very considerable reduction of the flow was sufficient, he had believed that the progress of an innominate aneurism might be arrested by simultaneous ligation of the common carotid and of the subclavian in its third portion. But afterwards, having reflected upon the means by which nature obtains a spontaneous cure, and upon the fact that some coagulum is found in every sac at the point where the circulation is least rapid, he had reached the conclusions that a reduction of the rapidity of the current was the first step in spontaneous cure, and that, as this reduction is at first necessarily slight, the process could be accurately imitated, and coagulation started by ligation of a single one of the branches of the artery, even of the third portion of the subclavian. But, as he had noticed in a case of almost complete spontaneous cure that the carotid was occluded, he thought nature should be still further imitated, and the carotid tied rather than the subclavian.

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[1] It is interesting to note that in the second operation he used an animal ligature, silk-worm gut, cut both ends short, and obtained complete union of the wound in three days. The patient died three months afterwards, apparently of kidney disease, and at the autopsy no trace was found of the ligature; the carotid was pervious throughout, and presented a "manifest dilatation a little more than an inch in length near its root, corresponding in position to the pulsating tumour that existed during life."

[2] Lancet, 1827–28, vol. ii.

I shall not stop to point out the objections to this argument; it is sufficient to show that the case which is quoted in its support proves, if anything, the contrary. The case is the well-known one of Mrs. Denmark, aneurism of the innominate with occlusion of the carotid, for which Wardrop tied the subclavian in its third portion. Pulsation returned in the carotid on the ninth day after the operation, but the disease was apparently cured, and remained so for more than a year, the patient dying twenty-six months after the operation in consequence of its return. At the autopsy the sac was found partly consolidated, with a channel of communication between the aorta and carotid, the latter vessel being pervious throughout, and the subclavian to within a quarter of an inch from the ligature, although its lumen was contracted. Wardrop assumes that the carotid carries off half the blood passing through the innominate, and that the branches of the subclavian and its third portion each receive one-fourth. By tying the subclavian, therefore, he diminished the outlet by one-fourth, but by the reopening of the previously occluded carotid it was increased by one-half, and the consolidation, which did not take place while the flow was reduced one-half, was produced during the subsequent increase of the flow, and therefore must have been due to some other cause than reduction of the amount of blood passing through the sac.

It seems evident that the distinction which has become classical among us between "Brasdor's method" and "Wardrop's method," as we understand the terms, was not recognized by Wardrop. According to his view of it, Brasdor's method was simply that of distal ligation, and included those cases in which branches intervened between the ligature and the sac, as well as those in which they did not.

Wardrop's teachings and practice have found many imitators. It is not my purpose to trace further the history of the method, and describe the numerous operations that have been done in accordance with it. That has been done in a most complete and masterly manner by Prof. Sands, in the paper to which I have already referred. I shall restrict my examination, therefore, to cases of simultaneous ligation of the common carotid and the subclavian in its third portion for the cure of supposed aneurisms of the innominata, an operation upon which considerable experience has accumulated since Prof. Sands's paper was published. The following account of an unpublished personal case may serve as an introduction to the subject.

CASE.—Patrick I., an Irish labourer, 34 years old, sought admission to Bellevue Hospital early in January, 1880, to be treated for severe pain in the right shoulder and neck. He was assigned to a medical division, and subsequently transferred to my care in the first surgical, the diagnosis of innominate aneurism having been made by several members of the visiting medical staff. The following notes of the case were taken immediately after his transfer:—

The patient is a spare, medium-sized man, of rather dissipated habits, but with no history or sign of syphilis. Ten months before admission (March, 1879) he first felt sharp pain in his right shoulder, running up to the back of the head, and noticed at the same time a lump in his neck above the right sterno-clavicular articulation. The pain lasted about two months, and the lump, he says, diminished for a time. The pain returned in four months, and has since continued with intermissions, becoming so severe about a month before he entered the hospital that he was compelled to stop work. The lump has lately increased rapidly in size.

On examination there is found a pulsating tumour at the root of the neck, rising an inch and a half above the clavicle, and extending from a point midway between the left sterno-clavicular joint and the median line three inches to the right, apparently displacing the sternal end of the right clavicle forwards. The skin covering the tumour is normal; there is lateral expansive pulsation, and a soft bruit with distinct transmission of the heart sounds. On percussion dulness is found less than an inch below the clavicle, increasing to absolute flatness over the tumour itself. There is no bulging of the ribs. The apex beat of the heart is one and a half inch below and to the inner side of the left nipple; both carotids beat strongly; there is a good radial pulse on the left, but none on the right side; weak pulsation can be felt in the right brachial artery. Pupils equal and dilated. No change in the voice; trachea not displaced to the left. The muscles of the right scapula are notably wasted, and the right arm is smaller than the left; the forearms are of equal size, the patient is right-handed, and has not noticed any weakness in his right arm.

The diagnosis of innominate aneurism, and the proposed method of treatment, were accepted at a consultation of the surgeons, and the operation was performed January 22d, in the presence of my colleagues at the hospital.

Each artery was exposed by a straight incision and tied with carbolized catgut, the carotid above the omo-hyoid, the subclavian outside the scaleni. Both ligatures were passed before either was tied, and no change occurred in the pupils or in the tumour when the knots were drawn. Each ligature was composed of a single strand of catgut, E violin string, No. 70, that had been kept in carbolized oil for two years; the knot was drawn with sufficient force to divide the middle coat of the artery. The operation was done antiseptically, the wounds closed with catgut sutures, a short drainage-tube inserted into each, and the whole covered with carbolized gauze, the upper edge of the dressing being fastened down by a broad overlapping band of adhesive plaster.

Pulsation was felt in the right radial artery just before the operation, and also in the subclavian after it had been exposed.

The constant movements of the patient's head disarranged the dressing, so that the carotid incision, and perhaps the subclavian also, did not remain protected antiseptically, but the patient made a prompt recovery, his temperature not rising after the second day above 99½°. Both wounds united primarily, except at the site of the drainage-tubes, and the subclavian incision was entirely healed by the 15th of February; the carotid wound was reduced by February 1st to a small, slightly oozing surface no larger than a pea, underneath which a firm mass as large as a filbert could be felt, apparently inflammatory induration between the skin and the ligature. By the 16th of February this hardness had disappeared, and the oozing surface had cicatrized.

The immediate effect of the operation was to relieve the pain in the shoulder and neck; it returned after ten days, and then disappeared permanently after the application of a blister. During the fortnight following the operation there was no change in the tumour, then the skin covering it became somewhat reddened, and the patient complained of an occasional sharp darting pain within the lump, and of a feeling as if the clavicle were being pressed forward. There was no accompanying fever, and the symptoms disappeared in a day or two. On February 25th it is noted that the lateral diameter of the tumour was only two and a half instead of three inches, and that it rose to a less height in the neck; the murmur had been barely appreciable for a fortnight, and the expansive impulse distinctly less. During the following fortnight it diminished rapidly in size, and by March 22d its lateral diameter was reduced to an inch, and its height above the clavicle to about three-fourths of an inch. It still pulsated. April 9th the tumour was barely visible, but could be felt as a hard lump behind, and rising half an inch above, the clavicle. Patient felt perfectly well, and insisted upon leaving the hospital.

In Prof. Sands's paper are to be found the details of three cases of this operation; Mr. Holmes, in his lectures upon the surgical treatment of aneurism,[1] collected three more; and to this list I have been able to add eleven, together with two in which the operation was attempted, but abandoned on account of the difficulty of exposing the vessels, and one in which there was an interval of two days between the operations upon the two arteries. The following table contains the seventeen cases first mentioned:—[2]

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[1] Lancet, 1872 to 1875.

[2] The second case given in the list in Agnew's *Surgery* is incorrectly reported there. Cuvellier tied the carotid and the subclavian in its first portion, not in its third; and the disease was known at the time to be a traumatic aneurism of the third portion of the subclavian, not of the innominata. The ligature was knowingly placed on the proximal, not on the distal side. The case is reported in full in Demme's *Militär Chirurgische Studien*, 2d part, page 116.

No.	Operator, and where reported.	Date.	Sex and age.	Result.	Cause of death, and result of autopsy.	Remarks.
1	C. Heath. Lancet, Jan. 5, 1867, and July 2, 1870.	Nov. 21, 1865.	F. 30	Recovered from operation. Died Dec. 8, 1869.	Hemorrhage from sac. Sacculated aneurism springing from right side of ascending aorta, with slight dilatation of the orifice of the innominate. (Path. Soc. Trans., vol. xxi., 1876.)	Pulsation was diminished.
2	Maunder. Lancet, Sept. 28, and Oct. 12, 1867, and Maunder's Surgery of the Arteries, p. 26.	Sept. 18, 1867.	M. 37	Died on 6th day.	Death attributed to obstruction of aorta by recent clot. Small aneurism of the arch of the aorta The sac was full of recent clot, continuous with one filling the arch of the aorta between the heart and the sac.	Operation rendered very difficult by œdema and distension of veins. Patient unconscious and cyanosed for 36 hours before death.
3	Hodges. Boston Med. and Surg. Journal, Aug. 6, 1868.	Apr. 11, 1868.	M. 55	Died on 12th day.	"Apparently exhaustion." No true aneurism. Innominate dilated to about three times its natural size. Much enlargement and atheroma of aorta.	Hemorrhage on 9th day from internal jugular, requiring a ligature.
4	Sands. Med. Record, Feb. 1, 1869.	July 16, 1868.	F. 43	Recovered from operation. Died 14 months afterwards.	Progress of disease Sacculated aneurism of aorta, pressing back and taking the place of the innominate.	Relief of symptoms; apparent arrest of the disease for several months.
5	Lane. Lancet, Jan. 13, 1872, and July 20, 1872, p. 69.	Sept. 20, 1871.	F. 40	Recovered from operation. Died about three months afterwards.	Rupture of sac externally. No autopsy. Holmes (Lancet, July, 1872) thinks the aneurism was probably of the aorta.	
6	Holmes. Lancet, July 20, 1872.	Nov. 16, 1871.	M. 50	Recovered from operation. Died Jan. 10, 1872.	Progress of disease. Aneurism of innominate, opening by a very large orifice into aorta. Almost filled with coagula, which were very adherent but not regularly laminated.	Catgut ligature. Lister method tried but abandoned because the dressings shifted. Tumor diminished at first, then increased rapidly. Galvano-puncture 2 weeks before death, followed after 2 days by rapid increase, redness, and œdema.
7	Durham. Quoted by Holmes, Lancet, 1872. vol. ii. pp. 37, 69.	……..	……	Died on 6th day.	Shock. Very large aneurism of innominate overlapping carotid.	
8	McCarthy. Maunder's Surgery of the Arteries, p. 22.	Oct. 16, 1872.	M. ..	Died on 15th day.	Hemorrhage from proximal side of the subclavian ligature.	
9	Ensor. Lancet, Feb. 6, and July 31, 1875.	Sept. 8, 1874.	M. 50	Died Nov. 12, 1874.	Hemorrhages from sac through carotid wound. Aneurism involved the whole of the innominate; semi-solid contents. Dilatation of the aorta.	The aorta was thought to be involved, and the operation was done to relieve pain. Patient, who was a Hottentot, improved for a month, then grew rapidly worse.
10	Weir. Oral communication.	June 22, 1876.	M. 45	Died on 15th day.	Rupture of aneurism into trachea. Aneurism of anterior wall of innominate, extending up in front of carotid; upper half of sac filled with laminated clot; rupture at lower edge of clot. Dilatation of aorta and of 1st inch of left carotid. Small proximal clot adjoining ligature in each vessel; branches of subclavian pervious and not enlarged.	

No.	Operator, and where reported.	Date.	Sex and age.	Result.	Cause of death, and result of autopsy.	Remarks.
11	Eliot. Am. Journ. Med. Sciences, Apr. 1877, p. 374.	Oct. 15, 1876.	M. 41	Died on 26th day.	Repeated hemorrhages from sac. Large aneurism of anterior wall of innominate. Aortic orifice of the vessel 2 inches in diameter. Sac occupied by laminated clot extending into the subclavian and carotid.	Subclavian ligature came away on 18th day; carotid ligature loose in wound at death. 3xss solution of persulphate of iron injected into sac on 17th day, after ulceration and first hemorrhage; this was followed by discharge of bloody serum for 3 days, and protrusion of a dry clot which fell out on 24th day, leaving a hole admitting three fingers.
12	King. Lancet, 1878, vol. i. p. 823.	Dec. 9, 1876.	M. 37	Recovered from operation. Died March 30, 1877.	Hemorrhages from a diverticulum of the sac which arose from its lower end and extended up in front of the carotid, communicating with an abscess which opened at the lower end of the carotid cicatrix March 27th. Aneurism occupied entire length of the innominate, and was filled by a firm clot which extended to the ligatures on the two arteries.	Catgut ligatures. Lister dressing. Tumour diminished and grew firm. Patient was fractious and left hospital Feb. 24th, returned Feb. 27th, having been drunk during all the interval, feeling miserably ill, and with redness and distension of the right carotid region which terminated in an abscess.
13	Barwell. Med. Chir. Trans., 1878, vol. ixi. p. 13.	Aug. 14, 1877.	M. 45	Recovered from operation. Died Nov. 24th, in consequence of exposure while intoxicated.	Pneumonia. Aneurism of aorta involving the anterior wall of the innominate and the origins of the right carotid and subclavian. Both arteries firmly plugged. Sac occupied by a firm laminated clot ¼ inch thick at thinnest point, with a central globular cavity 1 inch in diameter.	Catgut ligatures. Lister dressing. Tumour was reduced to a small hard lump behind the clavicle and was considered cured Oct. 22d.
14	Barwell. Med. Chir. Trans., 1879, vol. lxii. p 217.	Dec. 6, 1877.	M. 48	Died in 30 hours.	Never recovered from ether, remaining cyanosed and epileptoid until death. No account of autopsy.	The specimen was exhibited, but was not described.
15	Barwell. Med. Chir. Trans., 1879, vol. lxii. p. 217.	Dec. 6, 1877.	F. 37	Cured.	....	Catgut ligatures. Lister method. Tumour diminished, but pulsation persisted in protuberant chest wall. Left hospital Aug. 1878, married Feb. 1879.
16	Barwell. Med. Chir. Trans., 1879, vol. lxii. p. 217.	Jan. 17, 1878.	F. 27	Cured.	....	Catgut ligatures. Lister method. In April pulsation had ceased in tumour and chest wall. Patient was exhibited to the Society Dec. 10, 1878.
17	Stimson. Case herewith reported.	Jan. 22, 1880.	M. 34	Cured (?).	....	Catgut ligatures. Imperfect Lister dressing. 2¼ months after operation tumour reduced to a small, hard lump behind the clavicle.

In connection with this list we may consider also with advantage three other cases, which, strictly speaking, do not belong in it. They are those of Broca, Hutchison, and Speir.

In 1862, M. Broca tied the subclavian in its third portion, for the cure of an innominate aneurism, the carotid being and remaining occluded by pressure. Broca speaks cautiously of the result as a *demi-guérison.* The tumour solidified and the patient died of gangrene of the lung, "in no way attributable to the aneurism, which was filled with fibrinous clot, leaving a cavity in the centre of the size of a small fowl's egg, communicating above with the subclavian and carotid, and below with the aorta."

This account was communicated by M. Broca to Mr. Heath, and reported by the latter in the *Lancet,* July 2d, 1870, in connection with his own case.

In 1867, Prof. Hutchison[1] undertook the double operation, the patient being a man 48 years of age. The carotid was exposed through a V-shaped incision and tied near its origin, the intention being to tie the subclavian in its first portion, but as this was found to be impracticable, the vessel was sought outside the scaleni, and the ligature, as was supposed, applied to it there. No pulsation could be felt at the time in it or in the arm. Death was caused by suffocation on the forty-first day, the patient having been more comfortable, and his breathing easier until a few days before his death. At the autopsy an aneurism of the arch of the aorta and innominate was found, involving the orifices of the right carotid and subclavian which were separated about an inch. The sac was nearly filled with laminated clot which extended into the carotid to the site of the ligature, and into the subclavian beyond the origin of the vertebral artery, plugging both vessels. No trace was found of the subclavian ligature, and the continuity of the vessel was uninterrupted. Dr. Hutchison thinks the ligature must have been placed upon the sheath.

In both these cases the result sought by double distal deligation was obtained; that is, circulation through the sac was diminished or arrested —and therefore they may be taken into account in estimating the effect of the operation upon the disease. For the same reason may be added the reports of three autopsies; one, quoted by Prof. Sands, was made in 1843 by Deville and Bérard upon the body of a man who had died of aneurism of the subclavian. The third portion of the artery was occluded, as were also all its branches and both carotids; yet the aneurismal sac was not obliterated. The second is one reported by R. Douglas Powell;[2] a case of aneurism of the innominate in a man of 31, not recognized during life, in which the origin of the subclavian and the entire length of the common carotid were obliterated, while the sac was empty except for a few layers of fibrin at its upper part. Death was caused by rupture of the sac. The third[3] showed occlusion of the innominate and partial occlusion of the left carotid and subclavian in a case of aneurism of the arch of the aorta without production of clot.

In Dr. Speir's[4] case the operations were so nearly simultaneous that it deserves mention in this connection. Dr. Speir occluded the carotid by means of his artery constrictor Aug. 4, 1874, and tied the subclavian two days afterward, in a man 31 years of age, with supposed aneurism of the innominate. The patient died Sept. 7th, in consequence of repeated hemorrhages from the sac, over the apex of which the skin had sloughed. The autopsy showed a pouched aneurism of the summit of the arch of the aorta, the orifice of which was a semi-lunar rent 1¼ inches long. The innominate and its branches were healthy. The sac was filled with coagulum projecting through the orifice. The coagulation seems to have been due to inflammation of the sac.

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[1] Med. Record, 1867, p. 265.

[2] Path. Soc. Trans. 1869, vol. xx.

[3] Virchow's Archiv., vol. 73, p. 594.

[4] Arch. Clin. Surg. (N. Y.), Sept. 1876.

Finally, the operation has been attempted and abandoned in two cases, once by Dr. Cheever, of Boston, and once by Mr. Christopher Heath, of London.

Dr. Cheever[1] operated upon a man 38 years of age. Etherization was accomplished with much difficulty, on account of dyspnœa produced by the recumbent position, and anæsthesia was not obtained until after the lapse of twenty minutes and the use of eight ounces of ether. The patient then being livid, the ether was withdrawn and the operation begun. An attempt to tie the carotid having failed in consequence of profuse venous bleeding which made it impossible to find the vessel, the subclavian was next sought. This artery could not be seen, but it was felt and held under the finger while the needle was passed; as the point of the instrument emerged from beneath the vessel a smart gush of venous blood filled the wound, causing the patient to gasp and the pulse to disappear. In the effort to secure the subclavian vein, which was supposed to have been wounded, the incision was enlarged and the central portion of the clavicle removed, but the patient appearing to be moribund, his face blue, and his blood the colour of prune juice, the operation was abandoned. The patient died two hours afterwards. The aneurism was of the innominate, as large as an orange, and coated with a layer of firm fibrin. The vertebral artery was plugged.

In Mr. Heath's case[2] the patient was a man 45 years of age. He began the operation with the subclavian, encountering much bleeding and great difficulty in the search. At last he came upon a pulsating sac which appeared to be the aneurism extending further than was anticipated. So, considering the application of a ligature impossible, he plugged the wound with lint and tincture of iron. Bleeding recurred at intervals, and the patient died on the 6th day.

The autopsy showed a sacculated aneurism springing from the arch of the aorta in front of the innominate. The sac reached into the outer triangle of the neck, where it was seen during the operation, and where it ultimately gave way.

Of these twenty-two cases we may almost say what Mr. Holmes has said of the Hunterian operation upon the innominate and first portion of the subclavian, that they are a ghastly record of death and blood; but they present a measure of success, one that is not inferior to that of any other known method of treatment of this most formidable disease. There is, however, less to be gained by treating them as statistics and establishing percentages of success and failure, than by seeking what light they may throw upon the method and possibilities of cure.

The possibility of the cure, of the obliteration of the cavity, of an aneurism by complete distal occlusion has been demonstrated by operation and by spontaneous cure following impaction of a clot. Mr. Holmes claimed in 1872 that the same possibility existed in innominate aneurism, and he presented facts to "afford definite proof of the curative power of distal obliteration of the arteries in innominate aneurism." Of the six facts which he presents only two have any claim to be considered proofs, and even they are

[1] Boston Med. and Surg. Journal, May 6, 1869.

[2] Path. Soc. Trans., vol. xxii. p. 95.

not beyond reproach, because, although in each case the sac was filled with firm coagulum, there was still a small channel through which blood passed to the subclavian. One of these was a case of spontaneous cure by impaction; the other was the case in which Wright, of Montreal, tied the carotid. In the third case the left carotid was tied for aneurism of that vessel extending into the aorta; the upper portion of the sac became filled with clot, but rupture took place below into the lung. In each of the remaining three cases the subclavian was found occluded after death, and Mr. Holmes thinks that if the carotid had been tied a cure would have been effected. The list of such cases might be materially increased, but they are not "proofs." On the other hand, the specimens of Deville and Bérard, and of Mr. Powell, above referred to, show that total distal occlusion does not always produce consolidation.

So far as I know there are but two specimens that prove the possibility of such a cure. They are the ones furnished by Cases XII. and XIII. of this table, and even in one of these the permanency of the cure was destroyed by the formation of a second aneurism at the proximal border of the first. In addition we have Broca's case, a "half-cure" prevented perhaps from becoming a complete one by a fatal intercurrent disease, and, if clinical evidence may be accepted, Barwell's last two cases. (Cases XV. and XVI.)

The same specimens and cases show the possibility of a cure by a distal occlusion which is not complete, but only partial. They are all cases of occlusion of the carotid and of the subclavian in its third portion, and all, with the exception of Broca's, cases of double simultaneous ligation. There is also another case[1] which bears upon this point, although the aneurism was of the first part of the subclavian, not of the innominate.

The patient was a man forty-six years of age who fell while carrying a heavy load upon his right shoulder. The next morning he noticed a marked change in his voice, and soon afterwards a pulsating tumour appeared just above the right side of the sternum. Severe pain in the shoulder and neck caused him to seek admission to St. Luke's Hospital nine months after the fall. A pulsating tumour giving no murmur was found above the inner end of the right clavicle, measuring one and a half inches in lateral diameter, and extending one inch up the neck. Voice husky; right vocal cord paralyzed. The diagnosis of aneurism of the first portion of the subclavian was made, and Dr. J. L. Little tied the carotid and the subclavian in its third portion May 4, 1877. The tumour presented but little if any change during the following three months, and then diminished perceptibly during the fourth month after an attack of left hemiplegia and aphasia, which occurred July 23. The patient recovered partially from the paralysis, the left arm remaining somewhat rigid, and a year after the operation the tumour had almost entirely disappeared. He is still living, and there has been no recurrence of the disease.

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[1] Arch. Clin. Surg. (N. Y.), Oct. 15, 1878, p. 13.

It is especially worthy of remark that the two specimens (Cases XII. and XIII.) show that the partial arrest had become complete by the plugging of the entire length of the subclavian, and it seems not unlikely that the cure was effected first by the production of a clot in the sac in consequence of the slowing of the current, and secondly by the growth and extension of the clot into the subclavian. In no case, at least, do we find such plugging of the subclavian when the sac is not filled with clot, or when the aneurism has proved to be of the aorta; such cases present no exception to the rule that a clot does not extend backward beyond the branch nearest the ligature.

These two specimens and the other successful cases, including Dr. Little's, weaken the force of the objection often made to ligature of the subclavian in its third portion, that communication between the branches of that vessel and the sac is sufficient to defeat the object of the ligature.[1] They show that a cure can be accomplished notwithstanding it, but, on the other hand, it must be remembered that there are other cases to show that this complete occlusion does not necessarily follow, even after partial consolidation of the sac; just as obliteration of the sac may fail after complete distal occlusion.[2]

It is evident that factors other than mere arrest or retardation of the current are concerned in the production of a cure. One of these is the varying coagulability of the blood, and another may perhaps appear on examination of the conditions disclosed by the autopsies quoted above.

It is very well known that the tendency of blood to coagulate within the vessels varies under conditions, the influence of which is not entirely understood. It might be sufficient to refer in illustration of this fact to the spontaneous coagulation which takes place in some pouched sacs, and to the uninterrupted progress of the disease and entire absence of coagulation in others, or to the benefit sometimes obtained by absolute rest in the recumbent position; but there are other illustrations much more striking. The simple introduction of a hypodermic needle into a femoral aneurism and its retention there for an hour or two was sufficient in one case to start a consolidation that became complete, and in another case the similar introduction of six needles and their retention for four days produced the same result; while in a personal case the introduction of a loose bundle of horsehair, consisting of about fifteen pieces each six inches long, into an ilio-femoral aneurism, produced not the slightest change in the physical symptoms of the tumour during the month that elapsed before I finally tied the external iliac and cured the disease. Even the clot formed in a vessel on the proximal side of a ligature varies greatly in size, or may be entirely absent. After ligature of the carotid near its bifurcation the clot is frequently found to extend from the ligature to the origin of the artery, but in Case VI. there was practically no clot at all in either vessel. Such varying results, due to unknown and uncontrollable causes, might determine the success or failure of an operation.

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[1] Prof. Sands says: "It is not difficult to explain the failure of the various operations detailed. In all of them the branches of the subclavian . . . are left open, and the current of blood passes into them through the aneurism with sufficient force to prevent the deposition of laminated fibrin. . . . In no case does the cavity of the aneurism seem to have been obliterated." And Mr. Holmes says: "The ligature of the third part of the subclavian necessitates the continuance of circulation through the sac; and if so, the absolute obliteration of the tumour, its radical cure in the strictest sense of the term, making relapse impossible, cannot be obtained by this means."

[2] I have met also with one case of so-called spontaneous cure of an aneurism of the innominate, the vessels remaining pervious. It is reported in the *Path. Soc. Trans.*, 1873, vol. xxiv. p. 39, as a "solidified aneurism of the arch of the aorta and the innominata as large as a large lemon, with a direct channel of communication through it to the subclavian and probably also to the carotid. The coagulum was uniform in colour and texture, organized and laminated, and in no part was it soft or looking as though it was degenerating or breaking down."

Another element, important, I think, in determining the result, is the character and especially the size of the communication between the aneurism and the aorta. The twenty-two cases contained in this paper furnish eight autopsies bearing upon this point, Cases VI., IX., X., XI., XII., XIII., Broca's, and Hutchison's. In three of these (XII., XIII., and Broca's), the sac was filled with a firm coagulum entirely in one case, and with the exception of a central globular cavity in the two others. In two of these three the proximal orifice of the innominate was apparently of normal size; in the remaining one it was involved in the dilatation which included the adjoining portion of the aorta. In Case X. the orifice of the innominate was somewhat enlarged; as death was caused by rupture of the sac a fortnight after the operation, it was impossible to say what the ultimate effect might have been had life been prolonged. The specimen, which is preserved in the Roosevelt Hospital Museum, is suggestive of a possible cure.

In Cases VI., IX., XI., and Dr. Hutchison's, the orifice was very large, and in two of them formed part of a general dilatation of the arch of the aorta. They all contained some clot, but in all death was caused by the progress of the disease after the lapse of a period of time sufficiently long to have given the treatment a reasonable opportunity to effect a cure if it was possible.

The most, perhaps, that can be claimed for these facts, limited as they are in number, and incomplete in detail, is, that they do not conflict with the general impression that a narrow orifice favors consolidation. But when the aneurismal expansion includes not only the proximal orifice of the innominate but also the adjoining portion of the aorta, there is but little hope of obtaining a permanent cure by the operation. Laminated fibrin may indeed be deposited in the upper portion of the sac, and the advance of the disease may be arrested at that point, but the weakened wall of the aorta is not relieved from the strain, and the disease may progress there unchecked. The relief afforded, and the arrest of growth obtained recently in cases of aortic aneurism by ligature of the left carotid, may indeed inspire a hope of similar gain in cases such as we are considering, and this possibility must be taken into account in weighing the chances of an operation, but the gain, great as it may be, is far from being a cure of the disease.

I do not know if there are any preparations in existence showing the condition of the aneurismal wall and the nature of its connection with the inclosed fibrin after complete consolidation and cure. Pathologists have described the mode in which an aneurism enlarges, but are silent concerning the details of its contraction. We know that the tumour continues to diminish long after all pulsation has ceased in it, and that this reduction may be so extreme as to leave nothing but a barely recognizable nodule. Such a change is not compatible with the presence in the sac of the fibrin originally deposited there; it must disappear to make contraction possible. This disappearance is possible only through regressive changes in the fibrin, by its liquefaction and escape into the adjoining artery, or its absorption by invading tissue. Organization of a clot, in the sense of its direct transformation into living tissue by the ulterior development of the cellular elements of the blood deposited in it simultaneously with, or subsequently to, its coagulation, is an untenable, I may say an exploded, theory. Microscopical examination of a thrombus shows two sets of changes, one in the clot, the other in the vessel-wall. The fibrin softens, the vessel-wall proliferates, and the granulations springing from the latter penetrate into the clot or spread over its surface. It is to this growth that the attachment of the clot to the vessel is in great part due, for the granulations send out long interlacing processes into the interior of the clot, which bind the two surfaces together.

If now we apply to the aneurism the knowledge gained by a study of the thrombus, we have a possible explanation not only of its contraction, but also of the danger of a large proximal orifice. In a half-consolidated aneurism we find a clot that is closely adherent at the point were it presumably began to form, and loose at others, especially at its edge, where the clot has either grown rapidly or has been kept apart from the wall by an interposed layer of blood, so that the granulations have not had time to form or an opportunity to penetrate it. The blood, entering with full force through the large orifice, makes its way between the clot and the wall, and exerts upon the latter the same pressure that it would exert were no clot present, and thus the main condition necessary to the expansion of the sac, direct pressure of the blood upon it, is maintained. The very enlargement of the orifice of the innominate is in itself an evidence of weakness at that point, and adds force to an objection raised by Prof. Sands against the distal ligature, an objection based upon the usually unhealthy condition of the vessel-wall on the cardiac side of an aneurism. Case XII. furnishes corroborative evidence.

Both these conditions, the degree of coagulability of the blood and the size of the orifice, so potent in their influence upon the results of the treatment, are beyond our power to recognize beforehand, and they add another to the uncertainties of the diagnosis, already so great.

The term "supposed aneurism of the innominate," so frequently employed in the discussion of this subject, and in the record of cases, is a recognition only too well justified of the difficulties attending the diagnosis. The cases mentioned in this paper, together with three others[1] encountered incidentally in the search, in which some method of treatment other than the one now under consideration was adopted, furnish nineteen autopsies. In seven of these the aneurism was found to be purely aortic, in four it involved both the aorta and the innominate, in two there was dilatation of the aorta or of the aorta and innominate, but no true aneurism, and in only six was the innominate alone involved. When it is remembered that most if not all of these were hospital cases, and that the aid of others in the diagnosis was sought by the surgeon in charge, notably in some of the cases where the error was greatest, it is evident that the mistakes were the result not of ignorance or lack of care, but of the insufficiency of the diagnostic means at our disposal. And when it is further noticed that an aneurism of the aorta may extend up into the neck, overlapping and taking the place of the innominate, and even pass out between the scaleni, we are at a loss to understand how a correct and positive diagnosis can be made.

Such being the facts, what opinion should be held concerning the advisability of the operation? The answer to that question requires consideration not only of the percentage of success, but also of the possible amelioration of symptoms, of the value of alternative measures, and of the risk inherent in the operation itself. Two, three, or even four successes in a total of twenty-two cases is not a proportion to give much encouragement, but can a better one be secured by other means? The only other operations that can be proposed are the ligature of only one artery instead of both, or the application of the ligature to the subclavian in its first instead of in its third portion. Of the first, Prof. Sands records nineteen cases with only one recovery, and on theoretical grounds there is every reason to maintain that if anything can be gained by tying one vessel, more will be gained by tying two, and the risks of the operation are not materially increased thereby. The second (ligature of the carotid and of the subclavian in its first portion) has been done twice, the cases terminating fatally in six and fourteen days respectively. It is probable that with the aid of antiseptics a catgut ligature could be placed upon the first portion of the subclavian without much danger of secondary hemorrhage, but the presence of an aneurism would almost inevitably make it impossible to expose the vessel.

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[1] Two of these are included because the subclavian and carotid were tied, and the third, because it is contained in previous tables, although in it the carotid alone was tied. The cases are: (I.) One in which Hobart tied the carotid and first part of the subclavian in 1839. The patient died of secondary hemorrhage from the carotid ligature. The autopsy showed a pyriform aneurism of the aorta overlapping the innominate. The case is quoted by Mr. Holmes in the *Lancet*, July, 1872. (II.) One in which Mr. Knowles tied the right common carotid "for supposed aneurism of the lower portion of its trunk involving perhaps the innominate." The patient died three months afterwards of apoplexy, and the autopsy showed an aneurism of the aorta. (*Lancet*, 1868, vol. i. p. 750.) (III.) An unpublished case in this city. The common carotid was tied, and two or three years afterwards the subclavian, in its third portion, for supposed aneurism of the innominate. The patient survived the last operation about three years, dying in Bellevue Hospital in 1879 of phthisis. The specimen is preserved in the museum, but has been prepared by plaster injection to show only the collateral circulation. As well as can be made out in its present condition, there is no aneurism of the innominate, and only a uniform dilatation of the first six or eight inches of the aorta. The branches of the subclavian are pervious, and the supra-scapular is considerably enlarged.

Compression by means of temporary ligatures, silver wire, or specially devised instruments may be passed by without remark, since the principle is the same as that of distal ligation, and the risks of the operation little, if at all, less. Galvano-puncture is more dangerous than ligation, and the temporary introduction of needles has yet to be tested.

The only remaining alternative is the treatment by rest and restricted diet. All recent authors recommend in a rather perfunctory manner that this should be tried before resort is had to operative procedures; and in many of the above-mentioned cases it is recorded that this advice was followed without any apparent good result. The method is one that requires much fortitude and self-control on the part of the patient, while most of the cases come from a class who are but little accustomed to exercise any restraint upon their appetites, their passions, or their feelings. Even when aided by the moral effect of an operation and the physical weakness following it, it is often difficult to restrain them. In Hobart's case secondary hemorrhage was brought on by the patient springing from her bed in a fit of temper and throwing a pillow at the nurse. In cases V., XII., and XIII. death was hastened, if not directly caused, by the refusal of the patients to remain in hospital, and by their indulgence in liquor, notwithstanding their knowledge of the danger incurred by this conduct. In my own case the patient was a sullen, vindictive man, intolerant of pain, and impatient of control. The slightest or most quickly remedied neglect would excite in him a feeling of anger that would manifest itself for days whenever the offender came near him. An attempt to restrict his diet before the operation almost led to his leaving the hospital, and it was not until after the improvement in his condition had become manifest to himself that he was willing to remain quietly in bed. What could be expected in such cases from the treatment by rest and diet?

Although the operation has effected a cure in only two cases, XV. and XVI., or in four including cases XIII. and XVII., it has often been followed by a more or less marked amelioration of the distressing symptoms, a result which is a legitimate object of treatment when a radical cure is not possible, and when the means of obtaining it are not in themselves too dangerous. On the other hand, the operation hastened or caused death in five of the seventeen completed cases, and in both those in which the operation was abandoned after it had been begun; once, Case VIII., by hemorrhage on the fifteenth day from the seat of the subclavian ligature; twice (Case III. and Dr. Cheever's) by hemorrhage from the internal jugular or subclavian vein wounded during the operation; once, Case VII., by shock; once, Case II., on the sixth day by an unknown cause, possibly the progress of the disease, as the patient's condition was apparently desperate at the time of the operation; once, Mr. Heath's second case, by hemorrhage from the sac, which was exposed and weakened during the unsuccessful attempt to apply the ligature; and once, Case XIV., in thirty hours, by the persistence of an epileptoid condition attributed to the ether.

These facts speak for themselves, and the surgeon who refers to them will be guided by the values which he attaches to them, and the inferences he draws from them. The following conclusions are offered as a summary of a few of the points:—

I. A positive diagnosis of the origin and extent of an aneurism which has appeared behind the right sterno-clavicular articulation, and extended thence into the neck, is often impossible.

II. Simultaneous ligation of the carotid and of the subclavian in its third portion in cases of aneurism of the innominate, has been followed by complete obliteration of the cavity of the sac and of the entire length of the subclavian on the proximal side of the ligature; and in other cases, where the branches of the subclavian have remained pervious, consolidation has been so extensive as to leave only a small central channel, and the progress of the disease has been indefinitely arrested.

III. Therefore, the impossibility of safely placing a ligature upon the first portion of the subclavian is not a weighty argument against the treatment of innominate aneurism by distal deligation.

IV. Cases IV. and XIII., and the successes obtained by Mr. Holmes and Mr. Heath in the treatment of aortic aneurism by ligation of the left common carotid, diminish the objections arising out of the difficulty of making a diagnosis.

V. The operation deserves a position among surgical procedures of recognized gravity, but admitted propriety.

VI. Consolidation follows so slowly after the operation that the latter can do no good when the sac is inflamed or rupture is threatening.

VII. If the operation is undertaken when the aneurism is large and the breathing obstructed, no anæsthetic should be used.

NOTE.—*May* 20. Patient presented himself for examination. He was under the influence of liquor, and confessed to steady drinking since he left the hospital a month ago. The pulsating tumour, somewhat reduced in size since the last examination, could still be readily felt behind the clavicle. He complained of nothing except that his right hand was cold in the morning.